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# ***JPRS Report***

# **Science & Technology**

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***Central Eurasia:  
Engineering & Equipment***

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## Central Eurasia: Engineering & Equipment

JPRS-UEQ 93-004

### CONTENTS

26 May 1993

#### OPTICS, HIGH ENERGY DEVICES

- Ellipsometric Investigation of Ionic and Laser Irradiation's Effect on Optical Properties of Silicon's Near-Surface Layers  
[M.F. Galyautdinov, E.Yu. Karas, et al. *OPTIKA I SPEKTROSKOPIYA*, Aug 92] ..... 1
- Multiple-Longwave Single-Exposure Holographic Interferometry  
[A.M. Lyalikov, A.F. Tuvey, *OPTIKA I SPEKTROSKOPIYA*, Aug 92] ..... 1
- New Possibilities of Photosensitive Glass for Volume Phase Hologram Recording  
[L.B. Glebov, N.V. Nikonorov, et al. *OPTIKA I SPEKTROSKOPIYA*, Aug 92] ..... 1
- Liquid Crystal Light Modulators With a Fiber-Optic Frontal Window  
[B.G. Aleksandrov, M.V. Isayev, et al. *OPTICHESKIY ZHURNAL*, Apr 92] ..... 1
- The Effect of Precision of Correcting a Light Beam's Lower Aberrations on Its Energy Transport Efficiency [V.M. Buldakov, A.N. Glushkov, et al. *OPTICHESKIY ZHURNAL*, Apr 92] ..... 2
- Synopses of Articles Appearing in 'Optics Journal', April 1992 [*OPTICHESKIY ZHURNAL*, Apr 92] ..... 2

#### NUCLEAR ENERGY

- 1992 Safety Record at Nuclear Facilities Viewed [V. Menshchikov, *ROSSIYSKAYA GAZETA*, 9 Apr 93] ..... 5
- Official on Obstacles Confronting Ukraine's Nuclear Power Industry  
[Nur Rashytovich Nigmatullin, *DEMOKRATYCHNA UKRAYINA*, 30 Mar 93] ..... 6
- Kostroma Oblast Still Split Over AES Construction  
[Yuriy Vakhrin, *ROSSIYSKAYA GAZETA*, 20 Apr 93] ..... 8

#### MECHANICS OF GASES, LIQUIDS, SOLIDS

- Internal Source Optimization in Problem of Sphere in MHD Flow  
[V.I. Shatrov, V.I. Yakovlev, *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA*, May-Jun 92] ..... 10
- On Development of Oblique Waves in Planar Subsonic Boundary Layer  
[Yu.I. Bublikov, V.M. Fomichev, *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA*, May-Jun 92] ..... 10
- Variational Method of Plotting Subsonic Airfoil Profiles  
[S.M. Aulchenko, *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA*, Jul-Aug 92] ..... 10
- Effect of Reinforcement Structure on Ultimate Deformability and Strength of Shells From Oriented Glass Plastic Under Internal Explosion Loading  
[A.G. Ivanov, M.A. Syrunin, et al., *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA*, Jul-Aug 92] ..... 10
- Technical Stability of Dynamic States of Extended Rod With Variable Cross Section Moving Longitudinally in Fluid  
[K.S. Matviychuk, *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA*, Sep-Oct 92] ..... 11
- Effect of Planar Acoustic Pressure Wave on Stiffened Cylindrical Shell  
[N.I. Aleksandrova, I.V. Yefimova, *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA*, Sep-Oct 92] ..... 11
- Gas Dynamics of Pulsed Jets and Pressure Oscillations on Laser-Irradiated Target  
[N.M. Bulgakova, L.I. Kuznetsov, *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA*, Nov-Dec 92] ..... 11
- Investigation of Temperature Conditions of Bodies in Flows Under Gas Injection From Surface  
[V.I. Zinchenko, A.G. Katayev, et al., *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA*, Nov-Dec 92] ..... 11

# INDUSTRIAL TECHNOLOGY, PLANNING, PRODUCTIVITY

|  |    |
|--|----|
| Computer System for Automatic Weld Quality Assessment<br>[V.N. Put'syn, A.M. Schastlivtsev, et al., DEFEKTOSKOPIYA, Feb 92]                                | 13 |
| Analysis of Internal Weld Defect Recording Field Characteristics in Magnetic Tape Testing<br>[S.P. Mikhaylov, S.L. Vaulin, et al., DEFEKTOSKOPIYA, Feb 92] | 13 |
| On Issue of Ultrasonic Wave Interference During Propagation In Planar Contact Liquid Layer<br>[S.Ya. Gmyrin, DEFEKTOSKOPIYA, Mar 92]                       | 13 |
| Acoustic Method of Testing Welded Joints With Backing Plate<br>[V.M. Lantukh, DEFEKTOSKOPIYA, Oct 92]  | 13 |
| Equipment for Examining Translucence of Composites During Impregnation and Aging<br>[B.Ya. Demidenko, A.V. Sandalov, et al., DEFEKTOSKOPIYA, Oct 92]       | 13 |
| Experimental Studies of Ultrasonic Reflectance of Metal Surfaces<br>[A.K. Brovt'syn, DEFEKTOSKOPIYA, Dec 92]   | 14 |
| Acoustic Emission Quality Control of Steel-Titanium Clad Metal Produced by Explosion Welding<br>[B.A. Kuznetsov, DEFEKTOSKOPIYA, Dec 92]                   | 14 |
| Adaptive Control of Stepping Two-Legged Robot<br>[L.S. Shishkin, TEKHNIЧЕСКАЯ КИБЕРНЕТИКА, Mar-Apr 93]   | 14 |
| Programmed Motion Stabilization Algorithm of Mobile Robots<br>[S.V. Gusev, I.A. Makarov, TEKHNIЧЕСКАЯ КИБЕРНЕТИКА, Mar-Apr 93]                             | 14 |
| Synthesis of Automatic Systems of Coordinating Control With Relay Stabilizing Correction<br>[L.M. Boychuk, AVTOMATIKA, Mar-Apr 93]                         | 15 |
| Theory of Quantum One-Ports. Part 2. Transfer Matrices and Transmission Problems<br>[S.A. Smirnov, AVTOMATIKA, Mar-Apr 93]                                 | 15 |
| On One Example of Optimum Object's Transmission Through Specified Domain<br>[S. Ochilov, AVTOMATIKA, Mar-Apr 93]   | 15 |

**Ellipsometric Investigation of Ionic and Laser Irradiation's Effect on Optical Properties of Silicon's Near-Surface Layers**

937F0122A St. Petersburg OPTIKA I SPEKTROSKOPIYA in Russian Vol. 73 No. 2, Aug 92 pp 344-351

[Article by M.F. Galyautdinov, E.Yu. Karas, N.V. Kurbatova, Ye.I. Shturkov, Kazan Engineering Physics Institute, UDC 535.323+535.341.546.28]

[Abstract] The effect of ionic exposure and subsequent nanosecond-long laser annealing (NLO) on the electric and optical properties of semiconductors and their surface and near-surface layers, e.g., ion-implanted single crystals of Si with a [111] orientation, is discussed. To this end, an ellipsometry study of implanted and annealed samples is carried out at room temperature under an atmospheric pressure using a LEF ZM-1 laser ellipsometer emitting at a 0.6326  $\mu\text{m}$  wavelength with an optimum probing radiation incidence angle of 70°. The behavior of the complex refractive index in the 100 nm-thick near-surface layer in Si with electroneutral, electroactive, and inert gas impurities is investigated and the dependence of the refractive index and absorptance on the laser pulse energy density is examined within a 0-1.5 J/cm<sup>2</sup> range. The characteristics of the refractive index and absorptance behavior under laser irradiation of samples with the three types of impurity are analyzed and plotted and the ellipsometric parameters are calculated in the three-layer reflecting surface model approximation. The study makes it possible to examine the dynamics of structural transformations during laser annealing on the basis of the optical parameter behavior of ion-doped semiconductors. The authors are grateful to Ya.F. Fattakhov and L.Kh. Zakirzyanov for assistance. Figures 8, tables 2, references 8-6 Russian, 2 Western.

**Multiple-Longwave Single-Exposure Holographic Interferometry**

937F0122B St. Petersburg OPTIKA I SPEKTROSKOPIYA in Russian Vol. 73 No. 2, Aug 92 pp 388-392

[Article by A.M. Lyalikov, A.F. Tuyev, Grodno State University, UDC 535.818.8]

[Abstract] Applications of multiple-longwave holographic interferometry for controlling the measurement sensitivity in phase object probing and for identifying the contributions to refraction made by electrons and heavy particles in the course of plasma diagnostics are discussed and the difficulty of realizing single-exposure holographic interferometry while using a large number of wavelengths is mentioned. A method of recording a single-exposure hologram by using radiation with a large set of wavelengths for diagnosing transparent objects while controlling the measurement sensitivity is presented and it is demonstrated that when this hologram is exposed to two planar waves whereby the diffracted waves are separated by different diffraction gratings recorded at different wavelengths, one can control the measurement sensitivity of the reconstructed interference patterns within a broad range. The optical train of multiple-longwave single-exposure holography is shown and interference patterns of heat treated acrylic glass at a varying measurement sensitivity reconstructed from the same hologram are cited. By selecting the angle between two

planar waves at the reconstruction stage, one can reconstruct waves from different gratings and thus control the measurement sensitivity. The proposed procedure was tested experimentally. Figures 2, references 9.

**New Possibilities of Photosensitive Glass for Volume Phase Hologram Recording**

937F0122C St. Petersburg OPTIKA I SPEKTROSKOPIYA in Russian Vol. 73 No. 2, Aug 92 pp 404-412

[Article by L.B. Glebov, N.V. Nikonov, Ye.I. Panyшева, G.T. Petrovskiy, V.V. Savvin, I.V. Tunimanova, V.A. Tsekhomskiy, State Optics Institute imeni S.I. Vavilov, St. Petersburg, UDC 535.317.1]

[Abstract] The new possibilities of developing high-efficiency recording phase media being opened up by photo-stimulated phase transitions in organic substances from the amorphous to crystalline state, particularly a change in the refractive index induced by light during thermal development, and the possibility of recording volume holograms in photochromic glass are addressed, a new photothermorefractive material for recording highly efficient volume phase hologram, i.e., a multichromic glass, is proposed and investigated. The transmission spectra of multichromic glass—an Ag-containing photosensitive Na-Al-Zn silicate glass activated with Ce—capable of selectively absorbing glass, the dependence of the refractive index and transmittance behavior of multichromic glass on the ultraviolet radiation dose at various temperatures, the angular selectivity of volume holograms on multichromic glass, and the dependence of the relative diffraction efficiency on the hologram thickness, exposure, processing temperature, and processing duration are plotted. The findings demonstrate that holograms on multichromic glass are capable of storing data indefinitely and can be used for making holographic elements with large dimensions, regardless of their shape. Figures 11, references 10-6 Russian, 4 Western.

**Liquid Crystal Light Modulators With a Fiber-Optic Frontal Window**

937F0117B St. Petersburg OPTICHESKIY ZHURNAL in Russian No. 4, Apr 92 (manuscript received 24 Jun 91) pp 44-47

[Article by B.G. Aleksandrov, candidate of physical and mathematical sciences, V.I. Nikitin, All-Union Television Scientific Research Institute, Saint Petersburg, and M.V. Isayev, I.I. Kuzmina, and A.P. Onokhov, candidates of physical and mathematical sciences, State Optics Institute imeni S.I. Vavilov VNTs, UDC 535.241.13]

[Abstract] A spatiotemporal light modulator was developed on the basis of thin zinc selenide films that are transparent for reading light with a wavelength of 500 nm or higher. In the new light modulator the dielectric mirror has been removed beyond the confines of the photosemiconductor-liquid crystal structure and does not prevent the spatiotemporal light modulator from operating at a constant voltage. Another distinction of the new spatiotemporal light modulator is that it is powered by pulse voltage that connects and enriches the ZnSe-liquid crystal barrier, thus increasing the light modulator's speed. The new spatiotemporal light modulator was subjected to a series of experimental studies to evaluate its sensitivity, resolution, spatial noise level, and

speed. A type LG-52 helium-neon laser ( $\lambda = 633 \text{ nm}$ ) with an intensity of  $1 \times 10^{-4} \text{ W/cm}^2$  was used in the tests. The new spatiotemporal light modulator was found to have a threshold sensitivity (when operating on the basis of a hybrid effect) of  $4 \times 10^{-7} \text{ W/cm}^2$  with a contrast of 2:1. Total contrast (50:1) was achieved with a writing radiation intensity of  $2 \times 10^{-5} \text{ W/cm}^2$ . The new spatiotemporal light modulator was demonstrated to transmit six gradations of the resolution wedge of the IT-72 test table. When operating on the basis of an  $S$ -effect, the new spatiotemporal light modulator demonstrated a somewhat higher threshold sensitivity ( $2 \times 10^{-7} \text{ W/cm}^2$ ) and achieved full contrast at a writing radiation intensity of  $5 \times 10^{-6} \text{ W/cm}^2$ . Studies of the new spatiotemporal light modulator's noise characteristics established that its liquid crystal layer is the main contributor to its spatial noise. The mean square transmission deviation calculated on the basis of experiments for a modulator with a 2- $\mu\text{m}$ -thick liquid crystal layer in the spatial frequency band from 5 to 30  $\text{mm}^{-1}$  amounted to 6.8%, thus confirming the high quality of the liquid crystal's orientation. Studies of the new spatiotemporal light modulator's time characteristics established that the minimum light modulation cycle ( $t_{\text{on}} = 40 \text{ ms}$  and  $t_{\text{off}} = 70 \text{ ms}$ ) is achieved with a write pulse amplitude on the order of 20 V and an erase pulse amplitude of about 5 V. The signal-to-noise ratio in the spectral plane given an input signal frequency of 10 MHz at the maximum speed equaled 6, which corresponds to a threshold resolution of 30  $\text{mm}^{-1}$  for the cathode ray tube-spatiotemporal light modulator system given an image size of 20 x 20  $\text{mm}^2$ . Overall, the experimental studies performed thus confirmed that the basic characteristics of the new spatiotemporal light modulator are such that it can be used to create a hybrid cathode ray tube-spatiotemporal light modulator system with a large information capacity. Figures 3; references 7; 6 Russian, 1 Western.

#### The Effect of Precision of Correcting a Light Beam's Lower Aberrations on Its Energy Transport Efficiency

937F0117A St. Petersburg OPTICHESKIY ZHURNAL  
in Russian No 4, Apr 92 (manuscript received  
4 Jul 90) pp 7-9

[Article by V.M. Buldakov, candidate of physical and mathematical sciences, Atmospheric Optics Institute, Siberian Department, Russian Academy of Sciences, Tomsk, A.N. Glushkov, candidate of physical and mathematical sciences, and L.V. Streltsova, Astrofizika Scientific Production Association, Moscow; UDC 535.317.6:621.373.826]

[Abstract] A mathematical study was conducted to examine the effect of errors in correcting a laser beam's lower aberrations on the efficiency of transport of the energy concentrated in the beam's waist. Mathematical ratios were derived that link Shtrel's [transliteration] number with errors in correcting the lower aberrations of a partially coherent pencil of rays in the presence of large shifts of the beam from the target point that reduce Shtrel's number to 0.4. (Shtrel's number  $[K_{\text{sh}}]$  is generally defined as the ratio of the average intensity of a field at a point under its actual operating conditions to its maximum value  $I_{\text{max}}$ ). The expressions derived showed that increasing a beam's spatial coherence and relative size results in a decrease in the difference between the degree of the fluctuation and systematic error components. This finding was explained in terms of the fact

that as the said parameters increase, the beam's radius at its waist decreases, and Shtrel's number becomes more sensitive to the slightest deviations of the wave front's curvature from the required value. The analysis performed confirmed that when a light beam's lower aberrations are corrected to improve its efficiency of transporting the energy concentrated at its waist, the focusing and guidance errors must be reduced. Because transport efficiency depends on a beam's width and spatial coherence, the requirements imposed on an adaptive optical system's precision characteristics must be set with consideration for the values of the said parameters. Figure 1, references 5 (Russian).

#### Synopses of Articles Appearing in 'Optics Journal', April 1992

937F0117C St. Petersburg OPTICHESKIY ZHURNAL  
in Russian No 4, Apr 92 pp 71-72

[Synopses of articles appearing in "Optics Journal," April 1992]

[Text]

UDC 778.38.681.787

Holographic Lateral-Shift Interferometer, V.G. Gusev, pp 3-7

The operation of a holographic lateral-shift interferometer that uses diffusely scattered fields and that is intended for quality control of lenses and objectives is analyzed in a Fresnel approximation. The analysis demonstrates that by performing spatial filtration in the far-out diffraction zone, it is possible to isolate an interference pattern characterizing both axial and extra-axial wave aberrations of the lens or objective undergoing testing without the possible low quality of the interferometer's components changing the appearance of the interference patterns. Figures 4, references 10.

UDC 535.317.6:621.373.826

Effect of the Precision of Correcting a Light Beam's Lower Aberrations on Its Energy Transport Efficiency, V.M. Buldakov, A.N. Glushkov, and L.V. Streltsova, pp 7-9

Mathematical relationships are derived that link Shtrel's [transliteration] number to the errors in correcting the lower aberrations of a partially coherent light beam given large displacements of the beam from its target point reducing Shtrel's number to 0.4. The minimization of the focusing errors is determined by the radius of spatial coherence and width of the beam. Figure 1, references 5.

UDC 771.537.6

Estimating Resolution During Photocopying With the Build-up of Photographic Images, R.A. Yesin and V.I. Zolenko, pp 9-12

The ultimate possibilities of increasing resolution when photocopying objects by the method of building up photographic images during photocopying are analyzed. A semi-empirical relationship is derived that links the resolution in the built-up image with the resolution of the starting low-contrast negatives and number of buildups. The results of experiments to increase the resolution of photographic images by building them up during photocopying are presented. Figures 2, references 3.



UDC 621.373.52

Analysis of Errors in Measuring the Slope of the Phase Front of Optical Radiation by Using Hartmann Sensors, V.Ye. Kirakosyants, V.A. Loginov, and V.N. Timofeyev, pp 12-15

The dependence of the mean squares of the errors in measuring the local slope, average slope, and average (with respect to the aperture) derivative of the phase front of optical radiation on the noise and aperture size of a Hartmann sensor is investigated. Reference 1.

UDC 535.313

Algorithm for Certifying a Spherical Mirror Based on Three Interferograms, V. Gubin, pp 16-18

A mathematical apparatus is proposed for calibrating a spherical mirror based on three interferograms. It is noted that the nonideality of the starting front may significantly limit the precision of calibration. Figures 2, references 4.

UDC 621.383:621.397.3

Modeling Binary Random Light Fields of Amplitude-Phase Screens, V.F. Terzi, A.G. Konyukhov, and Ye.N. Pavlov, pp 18-21

An algorithm is proposed for synthesizing a binary random field simulating an amplitude-phase filter with specified autocorrelation characteristics. From the standpoint of its parameters, the binary screen synthesized is equivalent to a multilevel filter, i.e., its diffraction efficiency is close to 1. Random screens may be used to control the parameters of laser images and when modeling the passage of laser radiation through a turbulent atmosphere. Tables 3, figures 2, references 19.

UDC 681.786.3

Stability of the Characteristics of Goniometric Instruments' Optical Elements, M.P. Kolosov, pp 21-26

The effect of the main sources of geometric irregularity on the stability of the optical and other characteristics of optical elements is analyzed. The analysis is performed by way of the example of the passage of a ray (indicator hairline) through an optical test element. The effect that the physical parameters of the optical materials and dimensional characteristics of the test element has on the angular position of this ray is demonstrated. Table 1, figures 3, references 12.

UDC 535.41

The Hilbert Transform Method for Reconstructing a Phase Distribution Based on an Interference Pattern, M.V. Smirnov, pp 26-28

The method consists of transforming the function describing the cosinusoidal distribution  $C(x, y)$  in the interferogram to the Hilbert-adjoint function  $S(x, y)$ . The functions  $C(x, y)$  and  $S(x, y)$  linked by the Hilbert transform are described in terms of a complex function whose argument represents the phase distribution being sought. Figures 3, references 4.

UDC 535.345.67

Lyot Wide-Angle Quartz Filter, A.L. Aleksandrovskiy, T.A. Vinogradova, N.P. Depman, and V.V. Tarasenko, pp 28-31

The optical characteristics of an interference-polarization filter with large angle and line apertures are examined. The quality criterion of a filter intended to isolate a scattered signal against a background of light noise distributed at an angle is analyzed. The parameters of its components are optimized for the purpose of magnifying the signal radiation. Figures 4, references 9.

UDC 621.384.3:539.1.04

The Effect of Surface Relief on Bodies' Radiation Temperature, V.D. Mochalin, pp 32-34

The significant effect of surface relief on the radiation temperature of bodies irradiated by solar radiation is demonstrated by way of the example of a plate located together with an external medium under natural heat transfer conditions. Figures 4, references 3.

UDC 535.317.1

An Integral Criterion for Estimating the Quality of Optical Systems, I.L. Anitropova and V.A. Zverev, p 34-37

A version of an integral criterion for estimating the quality of optical systems that gives consideration to both a comparative estimate of the quality of an image formed by an actual optical system and its energy capabilities is examined. References 9.

UDC 535.317.61

Compensation for Spherical Aberration in a Mirror Optical System, V.A. Semin, pp 37-40

An equation system describing an optical system is derived. The problem is solved from a calculation of one mirror surface that is arbitrary located and that strictly compensates for the spherical aberration of all remaining surfaces, which are assumed to be known. The possibility of using the resultant equations to design optical systems with additional properties besides axial stigmatism (for example, aplanatic properties) is demonstrated. Figures 2, references 4.

UDC 535.317:681.3

Finding the Second Point of a Beam's Encounter With Regard to Second-Order Nonclosed Surfaces, Dragan Antoniyevich, pp 40-41

The author defines an ellipsoidal light condenser whose function follows from the familiar distinctive feature of a rotational ellipsoid, where the light beam of rays emanating from the ellipsoid's front focus is focused in its rear focus. To calculate the rays' course, the author uses transformed Feder [transliteration] formulas for second-order surfaces. To determine the intersection of a ray and second-order curve, the author selects a second intersection point and determines the reflection in it. Figure 1.

UDC 681.785.5

Spectrum-Scanning Device, Ye.D. Mishchenko and Yu.Sh. Akhunbabayev, pp 41-43

A device is described for scanning a spectrum by using stepping motors. It is based on the turning of several optical components of a spectral instrument at different increments. Implementing the proposed device in a spectrometer with a triple monochromator made it possible to reduce the

spectrum scanning time by a factor of 100 as compared with the time expended in the case of the step-by-step turning of one optical element. Figure 1, references 4.

UDC 535.241.13

Liquid Crystal Light Modulators With a Fiber-Optical Frontal Window. B.G. Aleksandrov, M.V. Isayev, I.I. Kuzmina, V.V. Nikitin, and A.P. Onokhov, pp 44-47

Liquid crystal spatiotemporal light modulators with a photosensitive layer based on thin layers of ZnSe and intended to be connected to cathode ray tubes are described. The results of experimental studies of the sensitivity, resolution, speed, and noise level of the spatiotemporal light modulators with parallel and line-by-line addressing are presented. It is shown that the basic characteristics of the instruments developed make it possible to create a hybrid cathode ray tube-spatiotemporal light modulator system with a large information capacity. Figures 3, references 7.

UDC 681.786.3

Analysis of the Errors of a Goniometric Instrument With a Quasi-ideal Coordinate System. V.A. Meytin, pp 47-51

The errors of a biaxial goniometric instrument with a quasi-ideal coordinate system are analyzed. Basic mathematical expressions are derived for estimating the instrument's precision and calculating its tolerances. Figures 2, references 2.

UDC [531.717:621.383.4'3]:681.3

Automated Opticoelectronic Profilometer. B.D. Borisov, P.S. Golubev, and A.S. Mishnev, pp 51-53

An automated profilometer that combines an optical micrometer with scanning along a coordinate has been created. The device uses the shadow method and a multi-element linear CCD-photoreceiver. Three profiles (six faces) are inspected simultaneously during size inspection of pipes and rolled stock with complex profiles (including products fastened to a stand). Table 1, figures 3, references 6.

UDC 548.55:539.37

Optical Properties of a Plastically Deformed Leuco Sapphire. N.L. Sibikina, I.I. Afanasyev, L.I. Belevtseva, V.N. Vetrov, B.A. Ignatenkov, and A.P. Kiselev, pp 53-55

Experiments based on the optical-polarization method have established the deviation of the optical axes from the radii

of a meniscus obtained by plastic deformation of leuco sapphire disks with a z-cut. Figures 3, references 3.

UDC 621.373.826.038.8

Absorption in Interference Coatings of Optical Elements of CO<sub>2</sub> Lasers Used in Manufacturing, pp 56-58

To create interference coatings for the optical elements of CO<sub>2</sub> lasers used in manufacturing, the authors conducted studies of absorption in half-wave layers produced by thermal vaporization in a vacuum from film-forming materials (lead, bismuth, barium, and sodium fluorides, zinc selenide, germanium, and lead telluride) on substrates of monocrystalline potassium chloride. Table 1, figure 1, references 6.

UDC [621.315.5:538.945]:539.216.2

Producing Yttrium-Barium Cuprate Layers for Superconducting Bolometers. I.I. Shaganov, O.P. Kononova, M.B. Krayukhin, A.D. Tkachenko, and I.A. Khrebtov, pp 58-62

A method is described for producing high-temperature superconducting layers of yttrium-barium cuprate based on layer-by-layer thermal spraying of the components on a leuco sapphire substrate. The possibility of using a photolithography process on a copper layer to form high-temperature superconducting bushings with a specified configuration is demonstrated. Table 1, figures 4, references 11.

UDC 681.7.053.35:681.7

Analytical Method of Determining the Elements of the Technological Process of Preliminary Diamond Grinding With Consideration for Machine Tool Kinematics. V.V. Travin and L.D. Ptitsyna, pp 62-66

An analytical method is presented for determining the size of a working feed path with consideration for the kinematics of the machine tools and the geometric dimensions of the tool as a function of workpiece shape and dimensions. Figures 4, references 4.

UDC 681.7.053.45:531.43

The Role of Friction Forces in the Process of Grinding and Polishing Optical Components in Machines Operating on the Basis of the Lapping Method. Yu.V. Ashkerov, pp 66-70

This article presents a model of a tool for fine diamond grinding and polishing based on Voight-Kelvin and Maxwell rheological models. The role that oscillations in the cutting zone and different friction modes play in the surface-machining process is examined. Figures 4, references 17.

### 1992 Safety Record at Nuclear Facilities Viewed

93EN03634 Moscow ROSSIYSKAYA GAZETA  
in Russian 9 Apr 93 p. 3

[Article by Valeriy Menshchikov, deputy chairman of the Russian Supreme Soviet's Committee on Matters of Ecology and the Efficient Use of Natural Resources, and Vladimir Yakimets, senior scientific associate of the Systems Analysis Institute "Nuclear Power Plants: If Forbidden, But Very Much Desired, Then Possible"]

[Text] Recorded last year at Russia's nuclear power plants [AES] were 205 malfunctions, 60 of which were a safety system failure. In 56 instances, the units were disconnected from the power network. In all, the number of shutdowns increased over the year by 19.2 percent.

This year began with malfunctions in the operating sequence at the Beloyarsk AES. On 29 January, it was necessary to make a decision about the repeated increase in its health protection zone, which was now comparable in area to that of the Chernobyl plant. And on 2 February, because of the loss of power to the constant current panel, the Kola AES' power-generating unit was disconnected from the network. Both of these incidents, on the international scale, pertain to the second level of danger.

What should be done? Remove from operation all plants with Chernobyl-type reactors? Revolutions in economics, alas, do not lead to anything intelligible. The portion of the AESs in the production of electric power is so great that abrupt actions will only aggravate the consequences of a revolutionary restructuring of the domestic industry. They are grievous enough as it is.

Moreover, the AESs' unthinking defenders now have an excellent weapon of defense—the government decree signed by Prime Minister Chernomyrdin. It is commonly entitled, "Questions of the Construction of Nuclear Plants on Russian Federation Territory." One could rejoice if it were not so disturbing the way the government makes decisions so important for all Russian citizens about the construction, renovation and enhancement or protection of projects which, as it has turned out, sometimes "go off like a gun."

The decree caused a storm of indignation among the ecologists. And a reciprocal reaction from the AES workers. The sides went after each other bluntly, the one side with an ammo clip of ecological complaints and the other with an arsenal of technical arguments. We will not weigh the strength of their arguments. We would do better to talk about the Achilles' heel of all the post-communist governments, which was, and remains, the lack of procedures for making and implementing decisions which meet the spirit and the letter of the law. The decree on nuclear power plants is an example of this.

Inasmuch as implementing it is impossible for an extremely trite reason, it violates a number of the country's already existing laws. Much in it appears to be unlawful: the decisions on the construction or completion of the AESs and on the "drafting in 1992-1993 of the corresponding materials for the long-term property survey and valuation of the siting of new nuclear power engineering projects on Russian Federation territory" prior to receiving a favorable finding of a state ecological appraisal. And, indeed, there may not

even be one. Just as there is not up to this very day with respect to the fully operating Balakovo, Kalinin and Kursk plants.

The addition of improved RBMK-type [uranium-graphite channel-type] reactors to the old ones also provokes a whole series of objections. The specialists, it is true, rule out the possibility of a repetition of an accident on the scale of Chernobyl, but it has been necessary to pay for the enhancement of the safety of their operation through a deterioration in the reactors' operating characteristics. And this is not the only thing. The concentration of radionuclides in the soil around the Kursk AES is 10-100 times higher than it was prior to its construction. The background radiation is still low, but after the completion of the construction of the new units, it may confidently be predicted that it will increase.

A question: how was it possible to sign this decree without an ecological appraisal?

In uneasy anticipation of a recurrence of Chernobyl, we read in it instructions "to permit as an exception" the start of construction at the sites of a whole series of AESs "prior to approval of the plans for the construction of these nuclear plants." How much money, apparently, our country must have, if the prime minister is deciding to release it for the development of something which may not be realized later. Not realized ever!

And the paragraph in the decree, which permits financing all these operations, openly violates the law "On Protection of the Environment" which allows money to be spent only for those programs and projects which have been backed up by a favorable ecological appraisal.

The long-term diversion of hundreds of billions of rubles from the federal budget will sharply reduce the government's capabilities in the social sphere, which are not very strong as it is, and will become a source of additional inflation. At the same time, the economic efficiency of the production of electric power using AESs is being called into question more and more in many countries, inasmuch as the hour of reckoning for the promissory notes presented by the nuclear pioneers is approaching. They did not doubt that the problem of radioactive wastes is not worth a wooden nickel.

But, up to this very day, there are no ecologically and economically acceptable methods for dealing with them. And this is converting the wooden nickel into gold: there is the threat of a sharp increase in the cost of the nuclear kilowatt-hour itself. The situation is also being aggravated by the increase in the AES operating expenses and the approach of an avalanche-like process for removing plants which have reached the end of their useful life from operation. We know just how costly the sarcophagus for the Chernobyl AES was.

Despite our unpopular law "On Protection of the Environment," all the plants mentioned in the government's decree are located near large reservoirs and in areas with a large concentration of people. It seems the lessons of Chernobyl have been poorly learned.

The social unacceptability of the decree lies in the fact that it and the procedure for its drafting resemble relics of the era of developed socialism. But, since the decree itself was drafted without advice from the people, it is not likely that their opinion will be taken into consideration in the future.



And this is foolhardy.... The program for destroying chemical weapons was drawn up in the same fashion. And it proved to be a complete fiasco for the entire world. Because of this "trifle"—they disregarded the opinion of the people living in the areas where it was proposed that the plants for destroying the poisons be located.

Russia made a promise to become a law-governed state. And this means that the highest executive authority should set the example for law-abidance.

### Official on Obstacles Confronting Ukraine's Nuclear Power Industry

934K0948A Kiev DEMOKRATYCHNA UKRAYINA  
in Ukrainian 30 Mar 93 pp 1,2

[Interview with Nur Rashytovych Nigmatullin, first deputy chief, Ukrainian State Committee for Nuclear Power, by Lyudmyla Blyshchik; place and date not given: "The 'Crooked Nail' Syndrome: Ukraine's Nuclear Power Engineers Are Confronted With the Threat of Paralysis"]

[Text] The Chernobyl variant of the "China Syndrome" shocked the world with such a tragic denouncement that could not be imagined in the worst nightmares of the directors of that film scenario about an accident at an American nuclear power station. Now we have another "syndrome" being diagnosed in our nuclear power engineering system—one which has been facilitated by the disruption of the previously integrated, All-Union technological cycle.

The medical people could compare such a state of affairs only with a renal insufficiency, which leads to the complete turning of the organism into waste products with all the consequences thereof. And what about the nuclear power people? What course of "treatment" should they choose. We requested Nur Nigmatullina, first deputy chief, Ukrainian State Committee for Nuclear Power, to speak about this in an interview.

**Blyshchik:** Nur Rashytovych, at the request of our newspaper you have already commented on the notification to the effect that four Ukrainian nuclear power stations are on the brink of shutting down due to Russia's refusal to accept radioactive waste products from our AES's [nuclear power plants]. We promised our readers that we would turn to a more fundamental discussion of this problem upon completion of the meeting between representatives of the Russian Ministry of Atomic Energy and the Ukrainian State Committee for the Nuclear Power Industry at the Zaporozhye AES. Would you kindly tell us what you and your Russian colleagues managed to agree upon.

**Nigmatullin:** In principle, an area of agreement had already been reached in Moscow at the time when an international accord was signed concerning scientific and technical cooperation in the field of nuclear power engineering. We operated within the framework of that document, fleshing it out and supplementing it in accordance with our specific, mutually advantageous interests. But it is certainly no secret that—within the former USSR—Russia had a nuclear monopoly. It was there that stations were planned and personnel were trained. Nuclear fuel was produced at Russian plants. And it was Russia which assembled it, processed it, and used it. Now we must take this state of affairs into account; and we have no other solution but to reach a mutually acceptable agreement.

These are not the kinds of problems which we can solve—let's say—in a year or two. Although, in the normal course of events, Ukraine should be thinking about its future security and gradually—step by step—developing its own nuclear-fuel cycle. Otherwise it will be difficult for us in the future. But for this purpose we require a great deal of capital investment.

For a monopoly is a very dangerous thing; at any moment it could become a powerful trump card in the political games which we ourselves now perceive in the relations between Russia and Ukraine.

I have said—and I repeat again—that the problem of utilizing spent fuel arose on political terrain, rather than on the level ground of reciprocity between nuclear power stations and their appropriate enterprises. Because we normally find a common language with them, and this was confirmed once again during our meeting in Zaporozhye. To my way of thinking, it was not in search of a good time that Lebedev, the director of the mining-and-chemical combine in Krasnoyarsk-26, flew to meet with the government delegates in Moscow and then came down here to Ukraine. He is no less a patriot for his own country, nor is he ignorant about matters of radiation safety. But, as a specialist, he understands better than the local politicians the total complexity of the situation to the point where—to do him honor—he is acting as a leader responsible for the fate of thousands of people who have been left without work. But certainly no special train hauling spent fuel from Ukrainian nuclear power stations arrived at that enterprise last year. The combine's capacities have remained idle, people have not received wages, and—in addition—even the local budget has suffered from this.

**Blyshchik:** But you will grant that the Krasnoyarsk Regional Council declared that it would not permit radioactive wastes to be shipped onto its own territory from abroad, even if it were to proceed according to the principles of the Russian government and close its eyes to that provision of the Law on Environmental Protection which—strictly speaking—prohibits this. The Siberians have rebuked Ukraine for being short in its deliveries of sugar, vegetable oils, and other food products with which we were—so to speak—supposed to pay for these services.

**Nigmatullin:** Figuratively speaking, this is a crooked nail which has been pounded into a board. It's difficult to pull it out. This is not even a matter of the Russian law. Nor is it in contradiction with the intergovernmental accord regarding cooperation in the field of nuclear power engineering. The law prohibits the import of radioactive wastes and materials, but spent fuel is not a waste product. We process it—while, at the same time, safeguarding it—and subsequently reprocessing it and return it in the form of fresh fuel. That is to say, this very same mining-and-chemical combine would have to extract and isolate from its accumulation plutonium, uranium, and other highly active materials in the process of reaction. A concentrate would be made from the above-mentioned materials, and it would be put to work again. And so the spent fuel certainly has a very high residual value—one to which we cannot fail to stake our claim.

Incidentally, this process is carried out all over the world. France, for example, reprocesses spent fuel-elements for

Japan and converts all components which can be re-used to good advantage. This is usually done for a certain fee. We, however, are proposing to the Russians that a Russian-Ukrainian joint venture be set up based at the Krasnoyarsk Combine, inasmuch as there is already a technological base located at that site. The directors of the Ukrainian nuclear power stations sent a proposal to the Regional Council that a meeting be held with the local leaders and that everybody discuss this matter together. The directors of the "Tvel" [fuel-element] enterprise and the above-mentioned mining-and-chemical combine also signed this proposal. For they all understand the absurdity of the present situation. This "crooked nail" is ruining the economy not merely of Ukraine, but also that of Russia.

All we can do is to hope that common sense will prevail here.

**Blyshchyk:** But what if it does not? You have already said that Ukraine has not shipped out any spent fuel for an entire year now. It's obvious that the AES's were not planned for the eventuality of the Soviet Union's collapse. And so we are stacking up these spent fuel casings at the various stations, but is that not creating a radiation hazard?

**Nigmatullin:** The situation is unusual, but not so dramatic as that. Certainly the AES technological cycle has provided the so-called wet places of concealment. If popular, these are specially constructed pools, filled with the appropriate solvent. The spent fuel from the reactors is placed in these pools, and—in accordance with the technology—they are cooled here for several years, and only after that are they transferred to the reprocessing plants.

The power units did not go on line in one year, and—therefore—the situation is varied. For example, at the first two units of the Zaporozhye and Rovno AES's the pools are already filled, and only an emergency supply remains. At the Khmelnytskyi AES the situation is also difficult, but at other power units there are still reserves. They will be sufficient at least for the present year. But unless we succeed in reaching an understanding with the local councils where the appropriate Russian enterprises are situated, we will have to shut down stations next year. But I don't think that matters will come to that point, although we have prepared alternative variants for any eventuality.

At the "Azovmash," which formerly produced containers for transporting wet fuel casings, orders have already been placed for the dry-type preservation of nuclear fuel directly at the Maydanchiki AES.

This will provide a sufficiently reliable covering with a system of cooling and control to measure up to the world standards for radiation safety. Such containers are designed to hold 12 casings each, and they have a preservation life-time of 20-40 years; this will give us the necessary "time-out" to achieve a fundamental solution to the problem. For even if we achieve a 100-percent agreement on cooperation with Russia, we must have our own, station-type covering procedure so as not to be subject to political pressure from a neighboring state. By the way, that is the way that spent fuel is preserved and safeguarded by the Americans, Germans, and French.

We also have the potential—in time—to make fuel for our own reactors here at home. Ukraine procures uranium ore

from Russia and thereby enriches that country's enterprises. The State Committee for Nuclear Power is now directly interested in developing our mining-and-extracting industry. Moreover, we have already included in our committee the mining-and-enriching combine at Zholtve Vody. By the way, Ukraine is the only country in the CIS which produces zirconium; the latter fills a "window" in the series of fuel-type elements.

In the future for machine-building plants such as "Pivdenmash," for example, we would also be able to arrange for the production of these fuel casings. But this will become a reality only on condition that Ukraine works out its own national program for developing a fuel-and-energy complex.

Nowadays, however, our life consists of an elementary struggle for survival. For the present year our stations, unfortunately, have only half the fresh fuel that they need, and looking ahead to next year, we can already see a problem. The fact of the matter is that our plants produce solid fuels for a certain time, and they need to be financed by rubles, which we do not have. Furthermore, we need quite a few of them—25 billion, and that's only for the first two quarters.

The realities are such that the Ukrainian economy is puffing and panting, out of breath from a shortage of electric power. But we could eliminate this shortage by putting three units at an AES on line; they are already at a high stage of readiness.

They are members of the new generation of reactors, outfitted with a system having the necessary protection in the event that extreme conditions occur. That is to say, they are completely reliable, but—for obvious reasons—installation operations have been "frozen."

**Blyshchyk:** Nur Rashytovich, I happened to read in the press that in Ukraine they are hauling wastes from one station to another....

**Nigmatullin:** I officially declare that no spent-fuel casings have ever been hauled from one station to another, nor has there been any scheme for doing so. Such a thing could possibly have happened within the bounds of a single AES, but in that case it would have been an unprofitable thing to do. For the system of unloading fuel is such that we have to shut down the power units, and that would hardly be feasible.

**Blyshchyk:** You have talked for an entire hour about Krasnoyarsk. But it is known that spent fuel from two units of the Rovno AES were previously received by Chelyabinsk.

**Nigmatullin:** They were prepared to accept them immediately. There was a delay because of the legal documents involved. Besides everything else, Ukraine does not yet have its own, properly trained military units for accompanying such transport. Nor do we yet have our own, special trains for this purpose. And so, here too, we have to ask for help from the Russians.

**Blyshchyk:** You have cited some problems which, perhaps are "not peculiar" to the State Committee for Nuclear Power alone. Do you find understanding and support in the government?

**Nigmatullin:** Yes. At last a structure has been created for administering the nuclear power complex. There is a special,



station. For some unknown reason, the operation of an oblast commission that the deputies had given the responsibility for resolving the fate of the uncompleted construction project was discontinued before it actually began. Today the oblast administration states that it has been unable to find anyone who wants to pick up the uncompleted project. Actually, everything is simpler—they did not look for them. For all these more than 2 years, Minatom [Ministry of Nuclear Energy] lived in expectation, waiting for the passions to subside somewhat, for the pain of Chernobyl to begin to be erased, for the new economic problems to push the ecological ones into the background. During that time there was a steady buildup of the pressure exerted by the department on the Kostroma authorities and the people of Chistobor and Buy.

The people of Kostroma received money to complete the construction of a temporary boiler room for the settlement last year only in exchange for their consent to continue the designing of the KAES.

Minatom, speaking on behalf of the Russian government, promises to finance the socioeconomic programs in the 30-kilometer zone of the future power station in exchange for canceling the previous decision of the oblast Soviet that banned the construction of the AES. That decision is necessary most of all for the department itself for self-financing and for guaranteeing the work orders of its own institutions and various OKV [special design bureaus] of branches that are related to it on a corporate basis.

The first serious construction item—the boiler room—is “famous” because several hundred tons of crude oil have leaked from its thermal reservoir, poisoning the ground, the forest, and the stream. Is it possible, under these conditions, to believe the assertions about the complete ecological safety of the future AES?

What are the arguments presented by the supporters and the opponents of the nuclear power station? This is what is on the “pro” side of the scales: the ten-percent deductions from the total amount of capital investments for developing the social sphere, for creating 20,000 jobs, and for housing construction for this labor army, the laying of new roads, including to Vologda and Yaroslavl, for a medical diagnostics center, and for the creation of a belt of individually owned farms. That’s not bad. However, this entire program encompasses only the 30-kilometer zone of the AES. None of the other inhabitants of the oblast will gain anything from these lavish expenditures. Therefore deputy Yekaterina Laskina, a member of the small Soviet, reasonably asks:

“What benefit do we derive from having neighbors like this? The people of Buy will begin living better than anyone else. But nothing will change in the situation of the people of Kostroma or Susasino.”

The system of proof given by the supporters of continuing the construction includes the 20-percent tax deductions for payment into the oblast treasury. That also is good. But no

one is rushing to explain that this will be after the AES begins operating, and, in resolving the problems that Kostroma Oblast is experiencing today, these promises are completely irrelevant. The sale of electric power at a privileged rate will also occur after the first power unit begins operating. And, once again, this will be in the confines of the 30-kilometers zone.

The social and industrial infrastructure of the nuclear power station, all its roads, communications means, the construction base, hospitals, and housing—everything that is necessary and without which the AES cannot be built and cannot be operated—is being presented as some kind of gift donated to the oblast, as some kind of good deed.

If the construction does continue, then it will be on new principles of interaction, when the local authority will not be a suppliant of the monopolistic department—that is the opinion of Aleksandr Yurkin, chairman of the oblast Soviet’s permanent commission for industry, transportation, and communications.

The Kostroma AES has been and continues to be the creation of USSR Gosplan, although that organization is now long gone. Just as, essentially speaking, Russia’s energy program no longer exists. A problem that continues to be a tremendous and unresolvable one for the country is the lack of a harmonious concept for the existence and development of nuclear power engineering in Russia.

Having proven to be the unwilling executors of the Union’s deceased nuclear departments, the Minatom officials are acting in the way that they have become accustomed to—from a position of strength *ad rigid dictat*.

According to a rough count, the chief tasks of Kostroma Oblast, which remains to a considerable degree an agrarian oblast, include the carrying out of an economic reform in the rural areas, the resolution of the questions of converting the three largest plants, the reorganizing of the timber branch, and the restructuring of light industry. Each of these tasks requires considerable investments from without, because the oblast’s own manpower and funds are insufficient. The renewing of the construction of the AES, as we have seen, does not guarantee the necessary infusions into the local budget. That is beyond the capabilities even of such an all-powerful department as Minatom.

As for power engineering, the people of Kostroma consume only one-fifth of the electricity produced by themselves from two TETs [heat and power plants] and the mighty GRES.

And if Russia truly needs a nuclear power station here, then it obviously would be worthwhile for the government to take some of the future income from operating the AES and invest it into the resolving of the oblast’s current problems. That would be an example of a balanced approach to resolving the nationwide tasks and the region’s problems, and an example of completely equal and civilized relations between the center and the region.



**Internal Source Optimization in Problem of Sphere in MHD Flow**

937F01184 Novosibirsk *PRILADNAYA MEKHANIKA I TEKHNIЧЕСКАЯ FIZIKA in Russian* No. 3/193  
May-Jun 92 pp. 30-38

[Article by V.I. Shatrov, V.I. Yakovlev, Novosibirsk, UDC 539.9]

[Abstract] The development of MHD propulsion systems for submarines and surface ships prompted an increased interest in the effect of electromagnetic bulk forces (EOS) on the hydrodynamic pattern of flow around the bodies propelled by internal sources of electromagnetic fields and an attempt to optimize the electric and magnetic potential distribution on the body's (a sphere with an internal field source) surface which minimizes the electric power demand for motion at a given speed. To this end, a full variational problem is formulated and the solutions of certain simplified variational problems are derived and analyzed. The variational problem is reduced to a nonlinear system of eight partial differential equations with relevant boundary conditions. A parameter which describes the efficiency of the MHD propulsion method—the ratio of the electric power demand to the mechanical power necessary for towing at the same speed—is introduced. It shows that the energy outlays for propelling a sphere with an MHD source are equal to 54% of the towing outlays and demonstrates the possibility of further lowering the energy outlays. Figures 6, tables 3, references 7-6 Russian, 1 Western.

**On Development of Oblique Waves in Planar Subsonic Boundary Layer**

937F01185 Novosibirsk *PRILADNAYA MEKHANIKA I TEKHNIЧЕСКАЯ FIZIKA in Russian* No. 3/193  
May-Jun 92 pp. 45-50

[Article by Yu.I. Bublikov, V.M. Fomichev, Reutov, UDC 532.536]

[Abstract] Traditional approaches to calculating the Reynolds number of transition flows are reviewed and an attempt is made to demonstrate that the assertion that "oblique waves are less susceptible to the transition to a turbulent condition" is erroneous even for a planar incompressible isothermal boundary layer in a plane-parallel approximation and to show that oblique wave may have lower Reynolds numbers at the loss of stability and higher values of the Re growth increment and as a result lower transition Reynolds numbers compared to normal waves. To this end, a planar subsonic laminar boundary layer of incompressible liquid on an isothermal surface is considered while the Navier-Stokes and continuity equations are used as the mathematical model. The stability analysis is reduced to finding the eigenvalues of the boundary problem, i.e. complex values as functions of the Re number and nondimensional frequency parameter. The problem is solved numerically on a computer by the improved orthogonalizing method. The study reveals that in contrast to traditional notions, oblique waves in a plane parallel subsonic boundary layer play a much greater role in the transition to turbulence and may have lower Re numbers, they also may serve as the cause of turbulence development. It is noted that that latter is due not only to the fact that the oblique waves' critical Re number may be considerably

lower but also to the fact that they have a three-dimensional structure even in the framework of the linear theory. The oblique wave amplification is explained in the framework of the linear hydrodynamic stability theory: the growing three-dimensional perturbations determined experimentally are Tollmien-Schlichting oblique waves which are unstable from the viewpoint of the linear theory while the excited wave falls within a frequency range in which the normal wave is more unstable than the oblique one. The authors are grateful to V.Ya. Levchenko for constructive discussions. Figures 6, references 8-6 Russian, 2 Western.

**Variational Method of Plotting Subsonic Airfoil Profiles**

937F01194 Novosibirsk *PRILADNAYA MEKHANIKA I TEKHNIЧЕСКАЯ FIZIKA in Russian* No. 4/194  
Jul-Aug 92 pp. 90-93

[Article by S.M. Aulchenko, Novosibirsk, UDC 539.9]

[Abstract] A method developed for improving the solution of aerodynamic airfoil profile analysis problems is presented. It is based on describing the flow with the help of a functional whose extremals are the perfect gas flow equations. The behavior of the second variation of the functional which makes it possible to identify the extremum and thus analyze mixed flows, including profiles in transonic flows, is examined. The current function through which all quantities contained in the functional are analyzed is approximated by an expansion in terms of the basis consisting of Laplacian eigenfunctions. The problem is then solved by determining the extremum in a finite dimensional space of the basis's weight factors while the value of the functional is calculated by approximating the integrand function with Hermit's polynomials. A profile with a sufficiently high critical Mach number (0.68) designed by constructing a quasisolution of the inverse boundary problem for Chaplygin's gas model is used as the initial profile. The findings confirm the high accuracy of the proposed profile design and analysis algorithm and the possibility of using Chaplygin's gas model for simulating the subsonic actual gas flow making it possible to develop efficient analysis methods by representing the minimum surface equation solutions through analytical functions of a complex variable. The author is grateful to A.F. Latypov for his interest in the study. Figures 3, references 3-2 Russian, 1 Western.

**Effect of Reinforcement Structure on Ultimate Deformability and Strength of Shells From Oriented Glass Plastic Under Internal Explosion Loading**

937F01198 Novosibirsk *PRILADNAYA MEKHANIKA I TEKHNIЧЕСКАЯ FIZIKA in Russian* No. 4/194  
Jul-Aug 92 pp. 130-135

[Article by A.G. Ivanov, M.A. Syrunin, A.G. Fedorenko, Arzamas, UDC 624.0174.46.8.06.7]

[Abstract] The outlook for using wound glass-reinforced plastics as load bearing members of large shell structures capable of localizing an emergency explosive energy release is assessed and the effect of the reinforcement structure on the ultimate deformation of glass-reinforced plastic cylindrical shells with open ends under an internal radially symmetric loading and the conditions of their failure during the first tension phase are examined experimentally. To this



end, cylindrical glass-reinforced plastic shells made by winding VM-1 fiber-based roving tapes impregnated with an epoxy binder on a service mandrel are investigated. Three types of shells are examined. A steel shell was used to suppress the bending failure mechanism during the tests. The findings show that for a wound oriented glass-reinforced plastic with a helical-circular reinforcement structure, the ultimate circumferential strain under dynamic tension does not depend on the spiral layer angle. The ultimate strain may serve as the material's strength criterion under dynamic loading. Thus, in addition to being the load-bearing element in the plastic, the glass fiber also determines the plastic's ultimate dynamic elastic characteristics regardless of the reinforcing angle. Figures 2; tables 2; references 8.

#### Technical Stability of Dynamic States of Extended Rod With Variable Cross Section Moving Longitudinally in Fluid

93F01204 Novosibirsk *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA* in Russian No 5(195)  
Sep-Oct 92 pp 97-105

[Article by K.S. Matviychuk, Kiev, UDC 531.36.534.1]

[Abstract] The motion stability of a long dynamic system is considered as the problem of stability of long rods interacting with an external fluid flow. The technical stability of a dynamic process is defined and the technical stability conditions of a long rectangular rod with a variable cross section and a rectilinear axis in the initial state being longitudinally transported in a moving perfect incompressible fluid is considered whereby the process is described by a nonlinear system of three partial differential equations with nonuniform boundary conditions. Sufficient technical stability conditions of the system are derived for finite and infinite time intervals and under an asymptotic technical stability. The conditions under which the system loses stability are formulated and the critical rod velocity formula is derived. For illustration, the critical velocity of rods is calculated: 38 km/h for a 2 km-long rod, 53 km/h for a 1 km long rod, and 75 km/h for a 0.5 km-long rod. The findings are obtained on the basis of the comparison method using Lyapunov's direct method. References 13. 11 Russian, 2 Western.

#### Effect of Planar Acoustic Pressure Wave on Stiffened Cylindrical Shell

93F01208 Novosibirsk *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA* in Russian No 5(195)  
Sep-Oct 92 pp 110-116

[Article by N.I. Aleksandrova, I.V. Yefimova, Novosibirsk, UDC 539.3]

[Abstract] The need to determine the applicability limits of various mechanical engineering and building designs and the lack of data on the behavior of bending stresses in stiffened shells necessitate the strength analysis of stiffened shells under pulsed loads. To this end, bending and membrane stresses and displacements in periodically stiffened shells under the traverse impact of a plane stepped pressure wave are assessed, the problem is formulated and solved numerically with the help of an expansion into a Fourier

series in terms of the angular coordinate and finite differences for the remaining coordinates. In particular, the nonsteady impact of a plane stepped pressure wave onto an infinitely long thin elastic cylindrical shell (either hollow or filled with the same liquid as outside) stiffened with bulk heads at certain intervals and placed in a perfect compressible liquid is considered. The incident wave front is parallel to the shell axis while the shell motion is described by linear equations of the classical Kirchhoff-Love theory and the liquid perturbations—by the wave equation for the velocity potential. The numerical results are compared to analytical data, the dynamic coefficient and the time at which the analytical and numerical results begin to coincide are determined. The numerical solution is derived with the help of the "cross" explicit finite difference procedure. It is shown that the null wave form makes the principal contribution to the stress while the first form contributes to the radial velocity. The axial bending stress is the highest in the stiffened shell. Figures 4; references 6.

#### Gas Dynamics of Pulsed Jets and Pressure Oscillations on Laser-Irradiated Target

93F01214 Novosibirsk *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA* in Russian No 6(196)  
Nov-Dec 92 pp 14-22

[Article by N.M. Bulgakova, L.I. Kuznetsov, Novosibirsk, UDC 533.6.011.535.211]

[Abstract] Pressure oscillations at a frequency on the order of 10 kHz which usually accompany the effect of high-power millisecond laser radiation (LL) on solid targets are discussed and it is speculated that they have a gas dynamic development mechanism. To check this assumption, an attempt is made to simulate the gas dynamics of the erosion flare numerically and compare the analytical data to the experimental results within a broad range of target irradiation intensity. To this end, a detailed experimental study is carried out in a VIKA vacuum pulse chamber by exposing the target to pulsed radiation at a 1.06  $\mu\text{m}$  wavelength and a 0.3 ms pulse duration at half-power through a long-focus lens. The numerical analysis is conducted in the framework of the full system of Navier-Stokes equations whereby the gas in the flooded space is set in motion, forming areas of subsonic flow which may substantially affect the entire flow pattern, the erosion flare is simulated by a sonic nozzle being instantaneously turned on. The study shows that the entrainment of the gas in the flooded space and its impact on the nonirradiated target edges are the principle mechanism by which the pressure fluctuations develop on the irradiated target. The consistency of the experimental and theoretical data points to the validity of the models used. Figures 5; references 19. 18 Russian, 1 Western.

#### Investigation of Temperature Conditions of Bodies in Flows Under Gas Injection From Surface

93F01218 Novosibirsk *PRIKLADNAYA MEKHANIKA I TEKHNICHESKAYA FIZIKA* in Russian No 6(196)  
Nov-Dec 92 pp 57-64

[Article by V.I. Zinchenko, A.G. Katayev, A.S. Yakimov, Tomsk, UDC 533.526.536.24]

[Abstract] The heat transfer along the generating line of a body in a high-enthalpy flow which may serve as an efficient

means of lowering the surface temperatures in the areas where the maximum thermal loads are reached is discussed and the solution of the problem of heating-up of a spherically blunted conical body in a supersonic flow is considered allowing for different flow conditions in the boundary layer with a gas injection from the spherical blunting surface. The effect of the flow conditions and gas injection rates as well as the shell configuration and thermal parameters of the material on the transient joint heat and mass transfer characteristics is examined. These characteristics are found by solving a system of equations which describe the behavior of the averaged quantities in the boundary layer, the energy

conservation equation for the porous spherical part of the shell, and the transient heat conduction equation for the conical section. A two-layer turbulent boundary layer model is used to describe the turbulent flow. The thermal flow and surface temperature distributions on an impermeable surface and on a surface with injection, the temperature dynamics, and the behavior of the heat transfer coefficients are plotted. The findings illustrate the effect of the heat transfer and injection on the heat and mass transfer characteristics and may be useful for interpreting aerodynamic experimental data. Figures 5, references 14: 11 Russian, 3 Western.

### Computer System for Automatic Weld Quality Assessment

93°F0113A Yekaterinburg DEFEKTOSKOPIYA  
in Russian No. 2, Feb 92 pp 11-13

[Article by V.N. Pittsyt, A.M. Schastlivtsev, V.G. Firstov, V.I. Buryak, G.P. Zenin, Scientific Research Introscopy Institute, Moscow; UDC 620.179.684.3]

[Abstract] The advantages of automatic digital processing of the X-ray imagery over traditional techniques employing X-ray film and an operator who serves as a decision device prompted the development of a hardware-software complex which consists of an optical scanner or an X-ray vidicon with a 6-8 line/mm resolution, a video graphics adapter with a graphics monitor, a microcomputer, and a software package which automatically analyzes the static radiographic images of the weld. The sequence of two-layer operations which involve filtering and binarization used in weld processing for identifying and classifying the defects is described. The optical scanner image input time (from an X-ray film) varies within 10-120 s in the 512x512 format or up to tens of seconds from an X-ray vidicon. The program execution duration depends on the number of defects and is equal to several minutes for 10 defects. For an IBM AT computer, the speed is 1.4-4 times higher. The complex is capable of detecting pores, cracks, incomplete welding, and inclusions. Tables 1, references 7. 5 Russian, 2 Western.

### Analysis of Internal Weld Defect Recording Field Characteristics in Magnetic Tape Testing

93°F0113B Yekaterinburg DEFEKTOSKOPIYA  
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[Article by S.P. Mikhaylov, S.L. Vaulin, M.I. Shur, V.Ye. Shcherbinin, Gornyy Altay Teachers Institute and Physics of Metals Institute at the Urals Department of the USSR Academy of Sciences; UDC 620.179.14]

[Abstract] The shortcomings and limitations of existing magnetic tape weld testing methods and the lack of proper weld and bead defect classification prompted an analysis of earlier experimental data in order to ascertain the effect of the size and occurrence depth of internal cylindrical defects in model welds with various configurations on the spatial topography of recording fields on various tapes in different magnetizing fields. The effect of the perfect weld geometry on the tangential component topography of the initial field and recording field at various magnetizing fields, the effect of the bead height and internal cylindrical defect occurrence depth on the tangential component topography of the initial and recording fields, the defect signal equalization on tape, the effect of the bead configuration and defects on the tangential field topography at a constant depth, and the use of the combined function for tuning off from the defect occurrence depth under the bead are plotted. The effect of the magnetic properties of the tape is discussed. It is demonstrated that generally, the defective weld's field forms three systems of charges on tape: only one of which correspond to the defect, while a perfect weld forms a single charge system. The bead height and the magnetization field strength are the critical parameters for magnetic tape testing. The need to update regulatory documents governing magnetic tape testing due to their sensitivity discrepancies is noted. Figures 7, references 13.

### On Issue of Ultrasonic Wave Interference During Propagation in Planar Contact Liquid Layer

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[Article by S.Ya. Gromov, K. Asnaya kuznitsa Shipbuilding Yard; UDC 620.179.684.3]

[Abstract] The lack of data regarding the interference phenomena during longitudinal wave propagation in a flat contact liquid layer prompted an attempt to analyze the ultrasonic wave interference by the method of mathematical modeling in order to determine the time structure of the ultrasonic pulse itself. It is shown that thus far, only the pulse amplitude or its envelope has been considered. Taking of the pulse time structure into account makes it possible to improve our understanding of various aspects of the interference process. It is shown to confirm that the pulse amplitude oscillates with respect to envelope and individual half-waves as a function of the liquid layer thickness and show that these oscillations depend on the pulse's time structure. The study also shows that the shape of the resulting pulse due to interference depends on the pulse frequency also oscillate depending on the liquid layer thickness. The number of pulses in the envelope has no effect on the extrema positions along the phase shift axis. Figures 8, references 4.

### Acoustic Method of Testing Welded Joints With Backing Plate

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in Russian No. 2, Feb 92 pp 53-57

[Article by V.M. Gromov, Kuznetskaya Heat Engineering Institute; UDC 620.179.17]

[Abstract] To improve the reliability of signals due to the gap between the base metal and the backing plate in acoustic nondestructive testing, the development of a new method of testing welded joints with backing which makes it possible to separate the signals from the backing face and the interface between the gap. The false echo signal amplitude and the signal sequence amplitude envelope depend on the design, i.e., the edge preparation, and the backing plate thickness as well as the gap width, the backing plate configuration, and acoustic parameters of the backing plate. The weld testing procedure is outlined and the testing criteria are formulated. Practical recommendations for testing specific joints, including those from automatic welding, are developed and the conditions for selecting the testing parameters are determined. This testing method is promising for high noise ambient testing of a wide range of power equipment welded joints. Figures 4.

### Equipment for Examining Translucence of Composites During Impregnation and Aging

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in Russian No. 2, Feb 92 pp 58-61

[Article by B.Ya. Gromov, V.V. Sandalov, Ya.Ya. Indulevich, G.M. Kuznetsov, Mechanics Institute at the Latvian Academy of Sciences; UDC 620.179.64.536]

[Abstract] The equipment for the Twelfth All-Union Scientific and Engineering Conference on Physical Methods

and Facilities of Nondestructive Testing held in September, 1990 in Sverdlovsk is summarized. The procedure and a system of computer-aided recording and processing of trans-luence measurement data developed by the authors at the Polymer Mechanics Institute at the Latvian Academy of Sciences for controlling the quality of threads, tapes, and polymer and composite products is described. Block diagrams of the system and the data processing procedure are cited; the dependence of the TS-11 glass fabric and LUP-01 carbon-reinforced tape transluence on the degree of binder saturation and the dependence of glass-reinforced plastic transluence on temperature on the seventieth day of aging are plotted. The system makes it possible to assess the physical and mechanical properties of composite materials and monitor the binder application during the reinforcing material impregnation; it is suitable for comparative tests of single-layer glass reinforced plastics under thermal and radiation aging. A decrease in transluence with an increase in the exposure duration and temperature and thermal and radiation aging is noted. Figures 5; references 3.

#### Experimental Studies of Ultrasonic Reflectance of Metal Surfaces

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in Russian No 12, Dec 92 pp 9-12

[Article by A.K. Brovtsyn, Obninsk Nuclear Power Institute; UDC 620.179.16]

[Abstract] Expanding uses of ultrasonic testing prompted an experimental investigation of the ultrasonic reflectance of metal surfaces widely used as reflectors in various instruments. To this end, a number of custom made and common instruments, e.g., an ELSAM unit by WILD LEITZ (Germany), a SNOL-1.6 electric furnace, a Dewar flask, and a UD2-12 ultrasonic flaw detector, were tested. The reflectance of pearlitic and stainless steel, aluminum and aluminum foil, brass, and copper was measured using plates with a different degree of surface finish. For comparison, reflectance of metal plates was measured simultaneously using ultrasonic signals and laser beams. The effect of the surface finish and temperature on the surface reflectance is examined and it is demonstrated that the higher the surface finish, the greater the ultrasonic reflectance. Figures 4, tables 3; references 8.

#### Acoustic Emission Quality Control of Steel-Titanium Clad Metal Produced by Explosion Welding

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in Russian No 12, Dec 92 pp 44-49

[Article by B.A. Kuznetsov, Prometey Central Scientific Research Institute of Composite Materials, St. Petersburg, UDC 620.179.17]

[Abstract] The formation of various types of defects and the resulting stresses accompanying explosion cladding of metals prompted the use of the acoustic emission method for controlling the quality of steel-Ti clad metal formed by explosion welding. Under certain conditions, the acoustic emission (AE) method makes it possible to assess the defectiveness at the microscopic level. Three versions of acoustic emission testing of clad metal are considered: signal recording directly after cladding, recording of signals generated in the metal under an additional stress field, and

signal recording during mechanical tests during spot checks. In contrast to the ultrasonic method, the acoustic emission method is more sensitive and makes it possible to make a comparative estimate of the degree of defectiveness. Test data make it possible to determine the level of service stress under which microcracking processes occur in the clad metal and thus establish the suitability of the clad metal blanks for making specific structures allowing for the operating conditions. Figures 2, tables 3, references 6; 5 Russian, 1 Western.

#### Adaptive Control of Stepping Two-Legged Robot

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in Russian No 2, Mar-Apr 93 pp 215-219

[Article by L.S. Shishkin, St. Petersburg; UDC 62-50]

[Abstract] The problem of controlling the stepping of a human-like robot walking on a horizontal plane whereby the values of the inertial parameters, i.e., the mass and moments of all robot elements, are assumed to be unknown to the control system, is considered for the purpose of teaching the robot to walk at a given pace at an average speed without falling down and without any phase constraint violations. An attempt is made to solve the formulated problem in the framework of the method of recursive objective inequalities and to check the method's capabilities with respect to the complex unstable system control task. To this end, a planar model of a two-legged robot consisting of a body and two articulated two-link legs controlled with the help of instantaneous impulse actions applied to the joints and at the ends of both extremities is considered. The joints are assumed to be perfect, i.e., without friction. The problem of control synthesis which makes it possible after a certain learning period to teach the robot to walk stably is solved with the help of the above recursive method. The task of walking on a sloping surface is addressed. Figures 3; references 5.

#### Programmed Motion Stabilization Algorithm of Mobile Robots

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in Russian No 2, Mar-Apr 93 pp 220-229

[Article by S.V. Gusev, I.A. Makarov, Institute of Science of Machines, St. Petersburg; UDC 531.8]

[Abstract] The use of mobile robots in computer-aided manufacturing, in cleaning up after industrial accidents, and in oceanic and space research is discussed and it is noted that the applications of such robots are constantly expanding. The need to develop an automatic system for controlling the motion of such robots—an "autopilot"—which would free the operator from the task of constantly controlling the robot is formulated and the problem of automatic control of the motion of mobile robots with a tracked or wheeled chassis and nonsteerable wheels is considered. It is assumed that programmed motion which defines the desired change in the robot coordinates is given; on this basis, control algorithms which make it possible to stabilize this programmed motion are developed. Kinematic and dynamic models describing the robot motion are examined and an adaptive control algorithm which ensures programmed motion stabilization with changes in the robot's dynamic characteristics is proposed. The program of motion stabilization is solved comprehensively. It is shown

that the algorithms maintain their stabilizing properties even in the presence of some noise in the control channel; the proposed algorithm makes it possible not only to efficiently assess the unknown dynamic robot parameters but also to improve the motion control quality. Figures 2; references 21: 10 Russian, 11 Western.

#### **Synthesis of Automatic Systems of Coordinating Control With Relay Stabilizing Correction**

937F0124A Kiev AVTOMATIKA in Russian No 2, Mar-Apr 93 pp 63-71

[Article by L.M. Boychuk, Cybernetics Institute imeni V.M. Glushkov at the Ukrainian Academy of Sciences; UDC 681.513]

[Abstract] A new method of stabilizing relay regulation for coordinating control systems—a new relatively unknown class of automatic systems intended for controlling the ratio between the output values of dynamic entities—is described. The new systems are structurally distinguished in that they have no external master inputs or command systems. The applications and principal approaches to the synthesis of coordinating systems are outlined, the general problem of coordinating regulator synthesis and the principles of its solution are formulated, and the design characteristics and principal features of the synthesized system as an analog of natural and artificial intelligence systems are examined. For illustration, synthesis of the two-layer control law, i.e., coordination with stabilizing correction, is analyzed using the example of a two-dimensional dynamic entity with continuous and relay regulation. The study is financed by the Ukrainian State Committee on Science and Engineering under Program 6.4.2. Figures 4; references 15: 12 Russian, 3 Western.

#### **Theory of Quantum One-Ports. Part 2: Transfer Matrices and Transmission Problems**

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[Article by S.A. Smirnov, Cybernetics Institute imeni V.M. Glushkov at the Ukrainian Academy of Sciences; UDC 681.513:530.145]

[Abstract] The study of quantum one-ports (*Avtomatika* No 1, 1993) is continued. An alternative procedure of studying quantum one-ports based not on the scattering matrix but on the transfer matrix is presented. The new approach makes it possible to structure the problem geometrically and thus obtain new findings and precise solutions to some important problems of electron transmission through quantum two-terminal networks. The quantum one-port transfer matrices of single-mode transmission are considered and interpreted geometrically. The problem of full transmission is formulated for two and three two-terminal networks with a single-mode condition and for an arbitrary number of one-ports. Two-dimensional spatial channels whose electron state is a superposition or mixture of electron states in physical channels (one for each mode) and transfer matrices of quantum two-terminal networks with multimode transmission are analyzed and full transmission in two one-ports with a multimode condition is examined. The findings confirm that the transfer matrix can be used as the basis of the quantum one-port theory equally as successfully as the scattering matrix. Simple expressions which connect the scattering and transfer matrices are derived, making it easy to select between the two approaches. The issue of tunnel scattering is addressed. Figures 1; references 4.

#### **On One Example of Optimum Object's Transmission Trough Specified Domain**

937F0124C Kiev AVTOMATIKA in Russian No 2, Mar-Apr 93 pp 88-90

[Article by S. Ochilov, Cybernetics Institute imeni V.M. Glushkov at the Ukrainian Academy of Sciences; UDC 519.9]

[Abstract] An object of a given mass which is equipped with a propulsion system developing a given force and moves freely and without friction along a horizontal straight line is considered and this object's equations of motion are derived. A new formulation of the problem of the object reaching the origin of coordinates from a given initial state in the fastest possible way is proposed and the conclusion is drawn that the new problem amounts to the optimum transmission through a given domain rather than the fastest arrival at the origin of coordinates. A formula for the shortest object transmission time (i.e., optimum transmission) through the specified domain is derived. Figures 2; references 1.



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